Revista Pensamento Contemporâneo em Administração

CHARACTERIZATION OF REVENUES AND COSTS IN THE OPTIMIZATION OF SMALL AIRPORT BUSINESS

CARACTERIZAÇÃO DAS RECEITAS E CUSTOS NA OTIMIZAÇÃO DE NEGÓCIOS DE PEQUENOS AEROPORTOS

Recebido em 06.03.2020 Aprovado em 10.06.2020
Avaliado pelo sistema *double blind review*
DOI: https://doi.org/10.12712/rpca.v14i2.40916

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Abstract

This study seeks to identify factors associated with both airports costs and revenues, specifically in the context of small airports. The main variables of airports costs and revenues, applied in small airports, and data from small Brazilian airports was analyzed using statistical and mathematical tools to propose ordinary equations for the relationships identified between the considered variables. The results show the main variables with significant impact on the management of small airports and, from this, the development of a mathematical model serves as a complement to report the cost structure, income and characteristics of small airports business.

Keywords: Air Transport. Enterprise Performance. Small Airports.

Resumo

O presente estudo tem como objetivo identificar os principais fatores associados ao desempenho financeiro de aeroportos que influenciam na manutenção da atividade empresarial, especificamente no contexto de pequenos aeroportos. A análise de dados secundários de pequenos aeroportos brasileiros foi feita utilizando ferramentas de análise estatística e matemática na proposição de equações ordinárias para as relações identificadas entre as variáveis consideradas. Os resultados demonstram as principais variáveis com impacto significativo na gestão de pequenos aeroportos e, a partir disso, o desenvolvimento de um modelo matemático foi utilizado como complemento para se relatar a estrutura de custos, renda e características de negócios de pequenos aeroportos.

Palavras-chave: Desempenho de negócios. Pequenos aeroportos. Transporte aéreo.

Introduction

Identifying key factors associated with airport structure management costs and revenues, passenger terminal maintenance, baggage handling procedures, as well as personnel, cleaning, lighting, and other costs, it is necessary to balance the finances of these organizations and, consequently, the maintenance of their commercial activities. Such needs are even more relevant in relation to small airports, which in Brazil correspond to most airport establishments, i.e., 64 of the 121 airports operating in the country's commercial aviation (ANAC, 2020).

Regarding airport costs, studies consider terminal physical characteristics, passenger movement, operating and non-operating expenses, and cargo handling within the airport (Li, 2014; Copper, 1987). However, there are theoretical limitations when considering the applicability of this cost structure in a small airport. In addition, the literature commonly analyzes airport costs and does not relate them to revenue variables.

Different studies consider aeronautical revenues, such as landing and takeoff fees, and non-aeronautical, as the use of airport parking (Graham, 2009; Kalakou, Psaraki-Kalouptsidi and Moura, 2015). Based on this, in the main econometric studies has been used to develop models of impacts analysis caused in the process. The present study seeks to identify the maim items of management costs of a small airport, their respective aeronautical and non-aeronautical revenues, in order to characterize the different variables associated with the financial performance of the small Brazilian airports units.

The paper first makes a literature review about airports revenues, costs and concepts of the small airports. From this, it was used as reference studies about revenues, as Graham (2019; 2009; 2008), and Borille and Almeida (2017). For costs, there are few studies on the topic, being used mainly Tsai and Kuo (2004) as a research source. In the small airports, it was used Hazledina and Bunker (2013), Lopes (2014) and Asaaf (2009) as references. Once this is done, it shows the method used, the results obtained and the final considerations on the theme.

Airport revenues

The concepts addressed in the airport revenues literature are categorized into aeronautical revenue (AR) and non-aeronautical revenue (NAR). The ARs come from the operation of aircraft at the airport in relation to the movement of passengers and air cargo. NARs are related to airport commercial activities, such as retail and leasing of commercial areas at the airport (Graham, 2008; Kalakou, Psaraki-Kalouptsidi and Moura, 2015).

The ARs, according to Graham (2009), can be identified through the landing and take-off rates, permanence and use of the airport structure during the aircraft circulation or permanence period, boarding fees, related to the cost compensation, landing fees arising from aircraft landing and take-off costs, and aircraft-related stay costs in the operating room and at the airport. The NARs can be identified, according to Borille and Almeida (2017), by the storage and control tariffs of goods at airports, and the foreman tariffs, which are responsible for the movement and handling of goods in the air cargo terminals. Thus, Graham (2009) classifies airport revenues according to Table 1.

Table 1: classification of airport revenues.

Aeronautical	Non-aeronautical
Landing fees	Retail, rental revenue and merchandise tracking
Boarding fees	Food and drinks
Aircraft parking fees	Car rent
Handling fees (if handling is provided by the airport operator)	Advertising
Terminal rental fees	Parking
Other aeronautical fees (air traffic control, lighting, air bridges, etc.).	Other non-aeronautical revenues (consultancy, visitor services and business).

Source: Graham (2009).

According to Table 1, the ARs deriving from aircraft operations, passenger and cargo processing and NARs come from commercial activities obtained at the airport terminal. The methods of analysis of the impacts of ARs and NARs on airport management available on literature, the econometric studies, using panel data models for airport financial studies, has often been used. Lei and Papatheodorou (2010), for example, quantify the financial performance of 21 UK airports analyzed during the period 1995/1996 to 2003/2004, linking low cost carriers (LCCs) with NARs. The authors present the impact ratios on airport commercial revenues (CR), as shown in Equation 1.

$$CR_{it} = \alpha + \beta_1 Lccpax_{it} + \beta_2 Otherpax_{it} + \beta_3 Locadv_i + \beta_4 Dutyfree_{it} + u_{it} \qquad (1)$$

According to Equation 1, the term *i* denotes the airports (*i* = 1, ..., 21) and *t* denotes the year (*t* = 1, ..., 9). The variables are represented by CR (real commercial revenue), in €, Lccpax (number of passengers carried by low cost carriers), Otherpax (combined number of passengers carried by FSC - full service carrier), Locadv (dummy variable to denote whether or not airport *i* is located in the London metropolitan area), Dutyfree (dummy variable used to designate the use of duty free shops at airports between 1999/2000 and 2003/2004), and u_{it} (bidirectional model error). The model-dependent variable's RNA, expressed as revenue from concessions, parking, baggage handling, parking and on-site property rental for airlines, car rental companies and other dealers.

The results obtained through regressions in the study by Lei and Papatheodorou (2010) were Lccpax equivalent to 2.87 (ranging from 1.97 to 3.76, with 95% confidence). Keeping the other variables constant, NARs can reach up to € 3.76 / passenger. The Otherpax coefficient obtained a value of 5.59 (ranging from 5.17 to 6.01). Keeping the other variables constant, the RNA found was € 5.59 and could reach up to € 6.01 / passenger. For the authors, the results are consistent, according to the BAA Annual Report (2004), as the net retail revenue per passenger equals £ 4.12. This difference in results from the report may be due to the model not only considering retail revenue, but also parking fee, property rental, car and baggage handling fees.

It's also noteworthy that the authors demonstrate that LCCs do not provide meals during the flight, causing passengers to spend on food in kiosks and restaurants, generating small commercial revenues for the airport. FSC passengers tend to travel for leisure and spend more time at the airport, purchasing higher value-added products at gift and personal stores, which generate higher commercial revenue when compared to LCC passengers. This explains the largest value found for the Otherpax variable.

To understand user's practices, Castilho-Manzano (2010) presents a study on passenger decision making within Spain's airports and finds the time variable as the main cause of the unit's revenue increase. By spending more time at the terminal, the likelihood of generating commercial revenue for the airport tends to be higher. In this sense, by increasing the number of passengers at airports and their waiting time, there is a theoretical tendency to increase revenue. However, Fasone *et al.* (2016) point out that in airport performance, the high concentration of people in airport corridors can lead to queues and passenger wear tends to discourage purchases, affecting unit revenues.

From an analysis of studies on this subject, it is noticeable that diversification within airports is financially beneficial for these organizations, increasing their financial efficiency through retailing as their main commercial source (Graham, 2009). However, it is necessary to analyze the financial performance model of each unit to identify the items that influence airport management, such as the movement of revenues within airports and which also generates airport costs, theme highly necessary for airport financial performance studies.

Airport costs

Planning and cost management are key to better control of airport financial performance. For Cooper (1987), the cost planning and management procedure takes place in two stages. In the first stage are the company's overhead expenses activities such as salaries, insurance payments and transportation. In the second stage, costs are defined by processes, products and services. Airport costs may vary and depend directly on the activities and services offered by the airport, as they depend on the area occupied by the service activities, the number of employees associated with these services and the revenue generated by the service activities (Pirttila and Hautaniemi, 1995; Kloock and Schiller, 1997; Tsai and Kuo, 2004).

Estimates used in the literature to quantify airport costs are largely presented from cases that use data envelopment analysis (DEA), correlation coefficients, regression models, and research that measure the relationship and efficiency between airport service and operating costs. In this sense, Li (2014) quantifies the airport costs of Magong Airport, a small airport located in Magong city, Taiwan, using a regression model of cost allocation between airports and airlines, expressed by Equations 2 and 3.

$$SC_1 = 3367064LN + 4227AA + 77CTA - 701PTA - 2698SFN \quad (2)$$

(t= 5.576) (2.368) (0.001) (-0.470) (-3.391)

R^2=0.984 F=189.045 N= 20

$$SC_2 = 2.6\,PE + 4168.8AA - 327.5CTA - 626.7PTA - 2662.2FN \quad (3)$$

(t= 5.576) (2.300) (-0.006) (-0.414) (-3.100)

R^2=0.984 F=184.045 N= 20

According to Equations 2 and 3, the model dependent variable is presented as SC (airport service costs). The other variables are denoted by LN (labor cost), AA (parking area), PE (unit personnel expenses), CTA (cargo terminal area), PTA (passenger terminal area), SFN (number of scheduled flights), PN (number of passengers), APN (number of arrival passengers), DPN (number of departing passengers), PCPH (peak hour passenger capacity) and AAC (amount of airport cargo). The main results obtained in this study are presented in Table 2, analyzed by the authors for the years 2000, 2003, 2006 and 2007.

Table 2: optimal values for dependent and independent variables.

Year	Number of workers	Parking area (m^2)	Freight terminal (m^2)	Passenger terminal (m^2)	Number of scheduled flights (n)	Airport costs (USD)
2000	59	25,164	460	5086	42,167	193,643,609
2003	56	44,000	1008	37,906	38,476	300,987,265
2006	61	44,000	868	24,738	34,822	316,827,650
2007	62	44,000	868	27,738	33,484	305,578,756

Source: Li (2014).

Table 2 presents the optimal values for the variables considered in the Magong Airport study, which can serve as a basis for optimizing the unit's airport operation. According to the author, in 2004 a new building was built in the passenger terminal, which increased the efficiency of the airport and explains the increase in costs in the 2003 and 2006 range. In this sense, the regression model proposed in Equation 2 shows that labor costs within the unit increase by approximately USD 3.4 million per year in the unit's airport costs. Equation 3 shows that annual staff costs increased by 2.6 times the annual airport costs. In addition, a scheduled flight reduces costs by USD 2,662 annually, increasing the unit's aeronautical revenue. The model proposed by the author suggests that the unit increase its number of scheduled flights, linking operational activities and cost allocation. Therefore, the size of the airport, in relation to its passenger movement, physical size and its personnel, has a direct relationship with the financial performance of the units, especially in the case of a small airport.

Small airports

Regarding the productivity of small airports, according to Hazledina and Bunker (2013), many studies relate physical production measures, passenger movement, aircraft movement, number of employees and number of runways. The size of an airport considered to be related to the movement of passengers and the movement of aircraft observed there. Small airports operate basic aircraft handling, passenger, maneuvering, and accommodation services, which may make them less efficient than units with a larger number of services (Assaf, 2009).

Thus, small airports suffer impacts such as capacity restrictions in the movement of passengers and receipt of large aircraft, absence of structure for commercial units, geographical locations that suffer from seasonal demands for travel. In addition to the centralization of travel in the main capitals of the country directly impacts the financial performance and operational efficiency of small airports.

Regarding the comparison of airport efficiency, Assaf (2009) relates the technical efficiency of 12 small airports and 17 major airports in the United Kingdom using a functional Cobb-Douglas model, as presented in Equation 4.

$$ln\, Y_{it} = \beta_o + \beta_1\, ln\, X_{1_{it}} + \beta_2\, ln\, X_{2_{it}} + \beta_3\, ln\, X_{3_{it}} + \beta_4\, ln\, X_{4_{it}} + \beta_5\, ln\, X_{5_{it}} + v_{it} - u_{it} \quad (4)$$

According to the author, the variable Y_{it} corresponds to the airport operating income, X_1 is the number of full-time employees, X_2 the operating cost, X_3 other costs considered, X_4 the fixed assets, t represents a time trend and v_{it} - u_{it} are the random model errors. The results obtained by the author are presented in Figure 1.

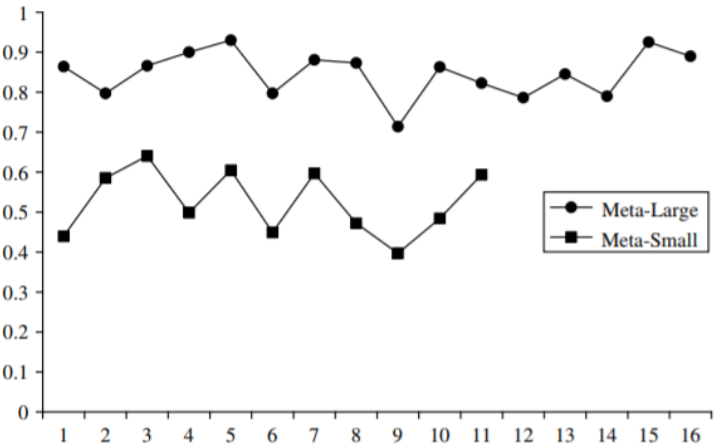

Figure 1: efficiency across Meta Border from small airports to large airports.
Souce: Asaaf (2009).

According to Figure 1, the results obtained by the author were that the average financial efficiency of small airports is lower than that of large airports, with only 52.6% of the parameters considered. This percentage is due to greater investments in large airports compared to smaller ones, achieving greater economies of scale. Differences in facility size, unit geographical location and runway length cause operational constraints on small units, for example, reducing passenger movement, which directly implies at airport revenues. To this end, it is necessary to identify the factors that are under the control of airports and the exogenous factors for the purposes of airport management.

Method

For a better understanding of the activities that make airport business optimized, one should identify the relationships between the variables that make up their financial performance. The main variables adopted in this study were the number of full-time employees (n), operating cost ($) and fixed assets ($) (Assaf, 2009), non-aeronautical revenue, revenue from unregulated activity ($), movement (n), amount of annual cargo (ton), terminal area (m²), number of stores and services provided (n), parking capacity (q), (Borille and Almeida, 2017), revenue from airports ($), number of passengers carried (n), type of company used (charter or full service), location of airport unit (Lei and Papatheodorou, 2010), labor cost ($), parking area (m²), unit personnel expenses ($), cargo terminal area (m²), passenger terminal area (m²), number of scheduled flights, number of passengers (n), number of arrivals (na), number of departure passengers (nd), peak hour passenger capacity (nhp) and amount of cargo carried at the airport (ton) (Li, 2014).

The main forms of data analysis in the literature refer to the use of econometric models and data sources have their limitations due to the limited availability of data, usually provided by the airport organization itself, or financial reports released by the airport management companies. Thus, it was necessary to define the variables considered in this study, presented in Table 3.

In this study, revenues and costs are segmented into aeronautical and non-aeronautical. The ARs are segmented into domestic and international boarding fees, domestic and international landing fares. The NARs are considered revenues from storage and foreman tariffs and unregulated activities that are generated by activities such as concessions, provision of services and activities without tariff regulation. The costs follow the same logic.

The airport size classification have been made using the Federal Aviation Administration (FAA) method, which adopts as a methodology that at least 0.05% and maximum of 0.25% of the country's shipments be made by the airport to be considered a small airport. According to the National Civil Aviation Agency (ANAC, 2019), passenger movement in Brazil in 2017 was 112,000,000. Therefore, to be considered a small establishment, the unit must have a minimum of 5,600 passengers and a maximum of 280,000 passengers carried throughout the year. In this study, calculations were performed for the 121 airports in the country and from these were identified the 64 small in this category used commercially, responsible for approximately 380,000 boarding (Infraero, 2017).

Table 3: variables used in the study.

Variables	Definition
TA	Passenger terminal area (m²)
CT	Cargo terminal area (m²)
PPH	Passenger capacity peak hour (n)
TC	Total cost per airport (USD)
NAC	Non-aeronautical costs by airport (USD)
AC	Aeronautical costs by airport (USD)
FR	Financial result by airport (USD)
PM	Annual passenger movement (n)
AM	Annual aircraft movement (n)
CC	Amount of annual cargo carried at the airport (ton)
PK	Number of parking lots
TAR	Total revenue per airport (USD)
AR	Aeronautical revenue per airport (USD)
NAR	Non-aeronautical revenue per airport (USD)
CU	Total comercial units (n)
FU	Feeding units (n)
SU	Service units (n)
RU	Retail units (n)

Source: research data.

In this study, only the airports administered by Infraero, a Brazilian airport management and operations company, were considered due to the availability and homogeneity of data that made possible a comparative analyzes. Of the 64 small Brazilian airports, 21 of them are managed by the company. However, 3 of them present inconsistent data and were eliminated from the analysis. Thus, the sample (n) considered is 18 units. Because they are administered by a public agency, the study can also serve as an airport management tool for the correct allocation of financial resources from public policies in the country. Table 4 presents the airports considered in the survey.

Table 4: small airports considered in the survey and their respective ICAO code.

Airports	ICAO
Juazeiro do Norte Airport	SBJU
Petrolina Airport	SBPL
Joinville Airport	SBJV
Santarem International Airport	SBSN
Rio Branco International Airport	SBRB
Imperatriz Airport	SBIZ
Boa Vista International Airport	SBBV
Montes Claros Airport	SBMK
Maraba Airport	SBMA
Campina Grande Airport	SBKG

Carajas Airport	SBCJ
Altamira Airport	SBHT
Cruzeiro do Sul International Airport	SBCZ
Uberaba Airport	SBUR
Tabatinga International Airport	SBTT
Tefé Regional Airport	SBTF
Pelotas International Airport	SBPK
Corumbá International Airport	SBCR

Source: research data.

The Multiple Linear Regression adopted, which analyzes the relationship between the variables considered in the problem, is presented in Equation 5.

$$\hat{Y}_i = \alpha + \beta_1 X_{1i} + \beta_2 X_{2i} + \ldots + \beta_k X_{ki} + \epsilon_i \quad (5)$$

i = 1, 2, ..., 18.

The variable $\hat{Y}$ in Equation 5 corresponds to the dependent variable of the model and *a* refers to the y-axis intercept or model constant, *β* the angular coefficient, *X* the dependent variable and ϵ the error not explained by the model. While the simple regression model results in a straight-line equation, multiple regression generates a plane and from a set of independent variables, and the model seeks to explain a dependent variable (Bakke *et al.*, 2019).

To relate the different variables associated with the financial performance of a small airport, a general equation is started, according to Equation 6.

$$FR_i = TR_i - TC_i \quad (6)$$

i = 1, 2, ..., 18.

The variable FR corresponds to the financial result per airport, *TR* the total revenue, *TC* the total cost and *i* denotes the airport considered. As the study considers total revenues and total costs divided into aeronautical and non-aeronautical, Equation 7 can be obtained.

$$FR_i = (AR_i + NAR_i) - (AC_i + NAC_i) \quad (7)$$

Being the NAR variable corresponding to non-aeronautical revenue, AR to aeronautical revenue, NAC to non-aeronautical costs and AC to aeronautical costs, stratification were made to allow the application of the model to estimate each parameter of Equation 7 per airport. Thus, it is possible to estimate each variable and apply in Equation 7 to obtain a general model of airport financial performance. As the study is divided into four individual regression models, analysis and diagnostic studies are required for each step variable. First, a correlation study of the dependent variable in relation to the independent variables considered in the study for the four models is performed through graphical analysis. From this, the variables that do not have a linear relationship with the dependent variable are disregarded before the mathematical simulations.

When entering variables and generating the model, the ANOVA test was used for all models, a procedure used to compare the distribution of three or more groups in independent samples (Bakke *et al.*, 2019). According to the test, for the generated regression to be valid, the sum of the squares of the regression must be greater than the sum of the residuals. In addition, the generated significance must respect the 95% confidence level adopted in the research, that is, be less than 0.05 for the model to be more valid than using the average as a prediction of the output.

Thus, it is necessary to interpret the general summary of the regression. In this step it was analyzed the adjusted R^2 value that helps in choosing the best data fit given by Equation 8.

$$R^2 ajust = 1 - \frac{n-1}{n-(k+1)}(1 - R^2) \quad (8)$$

This parameter penalizes the inclusion of little explanatory independent variables (X), because when comparing the simulations generated, if this value increase means a better fit of the model data. In addition, the Durbin-Watson statistic value, calculated by Equation 9, is generated. This value detects the presence of self-correlation between the residues generated by the regression. For this condition to be satisfactory, the independence of the errors must be satisfied. For the 95% search confidence level, the value generated should not be less than 1 or greater than 3.

$$dw = \frac{\sum_{i=2}^{n}(e_i - e_{i-1})^2}{\sum_{i=1}^{n}(e_i{}^2)} \quad (9)$$

In Equations 8 and 9 n refers to the number of observations, R^2 the value generated in the model, e the non-null eigenvalues and *dw* the Durbin Watson value.

The analysis of the values of the coefficients generated by the regression using the least squares method can be identified in Equation 10. At this stage, the significance test of each variable was also performed. The value must respect the confidence level of the survey. Once this is done, collinearity tests are performed by analyzing the value of VIF and TOL, as shown in Equation 11. The value generated in VIF cannot be close to 10 and the value of TOL cannot be less than 0.02 to not display signs of collinearity. Variables that do not meet the requirements are removed, and from there, a new model is generated, analyzing the possibility of inserting new variables and turning to step 1 of the process.

$$\beta = \frac{\sum_{i=1}^{n}(X_i - \bar{X})(Y_i - \bar{Y}_i)}{\sum_{i=1}^{n}(X_i - \bar{X})^2} \quad (10)$$

$$VIF_j = \frac{1}{1 - R_j^2} \quad (11)$$

In Equations 10 and 11, the β refers to the estimated parameter, X the regression "x" parameter, Y the regression "y" parameter, $\bar{X}$ the sample mean "x", $\hat{Y}$ the sample mean "y", VIF the measure collinearity analysis and R^2 the regression determination coefficient on the explanatory variables.

The model applied for the three years considered and individualized regression studies are performed for each year. From this, it generated four equations for the variables AR, NAR, AC and NAC for each year *t*, generating a general three-year analysis equation for a better representation of the impact of the variables considered on airport financial management.

Results

The results presented come from data analysis through statistical instruments and mathematical analysis in the proposition of ordinary equations for the relationships identified between the variables. These are considered so that the results present the positive or negative impact of each variable considered. Figure 2 presents the average results of the small airports financial results for the period from 2014 to 2018.

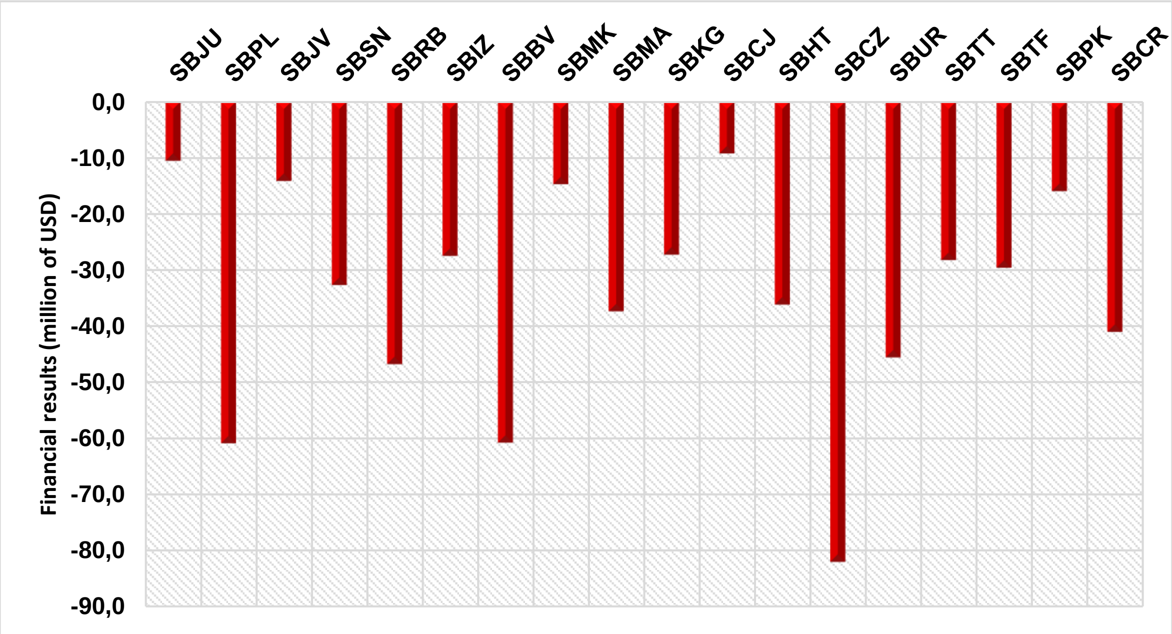

Figure 2: financial results by airport considered in the survey.
Source: research data.

As shown in Figure 2, the airports considered presented financial loss during the period, with Cruzeiro do Sul International Airport (SBCZ) being the worst performing. This can be explained by the fact that it is a unit with low passenger and cargo handling, few commercial food, retail and service units, which reduces the revenue generation for the airport. From this, it is necessary to understand the variables that influence the negative financial performance of these organizations. Table 5 presents the regression results, already calibrated for the 4 models considered in the study and for the 18 airports considered in the survey in 2014 and 2015.

	Model 1 *(NAR) Coef β1/∈1	β standardized	Model 2 *(AR) Coef β1/∈2	β standardized	Model 3* (AC) Coef β1/∈2	β standardized	Model 4* (NAC) Coef. β1/∈2	β standardized
CTE	1391689,344*** (239684,847)	-	974,94 (-0,965)	-		-	195120,99*** (249825,567)	-
CT								
PPH								
NAC								
AC								
FR								
PM	2,504 * (-0,98)	0,980	1,967* (0,0944)	0,999				
AM					156,33* (144,079)	0,714		
CC	-0,298* (0,146)	-0,193						
PK								
AR								
NAR								
CU	-36066,255**	-0,770					11660,542* (14055,64	0,447
FU	36070,381** (32865,66	0,252						
SU								
RU	35366,824* (38305,678)	0,733						
TA					821,229* (506,907)	0,619		
R^2 ajusted	0,959		0,997		0,920		0,794	
Durbin-Watson	2,779		1,894		1,610		1,926	
Significance testo f model	p valor =,000		p valor = ,000		p valor = ,001		p valor = ,0002	

Table 5: model results.
Source: research data.

As shown in Table 5, the blanks mean that the variable did not pass any of the statistical tests performed individually and in general analysis. In addition, the conversion rate of the local currency (Brazilian Real) BRL to the international reference (US Dollar) USD was 1 USD = 3.90 BRL.

In relation to the model 1, the dependent variable is the Non-Aeronautical Revenue (NAR), in which the explanatory variables entered were NAC, PM, CC, CU, FU, RU, SU and TA. The variables peak hour passenger, aircraft movement and number of parking lots did not correlate with the dependent variable and were therefore removed from the analysis. In making the first simulation, the commercial service units and passenger terminal area were not significant in the model. This can be explained by the few service units in small airports, generating negligible revenue values. The terminal area, on the other hand, is due to the fact that the size of small airports is mostly homogeneous, not significantly impacting the model.

Non-aeronautical costs, passenger movement, amount of cargo transported, total commercial units and retail commercial units presented correlation and level of significance in the model, not being identified multicollinearity between them and maintained in the regression as explanatory variables for NARs. The generated value of adjusted R^2 was 0.959, being increased and entering the input variables. The Durbin-Watson probability of 2.779 respected the limits considered, which demonstrates a better level of sample fit and residue independence, meeting the regression model assumptions.

The variables CC and CU had negative impacts on the model. Air cargo handling, keeping the variables constant, has an impact of - USD 0.298 and a low standardized β value, i.e., little explanatory force in the model. This may be due small airports tend to have low air cargo movements and most of them have no structure for storage and control of goods, providing the generation of storage and capacity charges linked to airport NARs. For the total of commercial units, the impact is also negative, - USD 36,066.255 in the value of NAR. This makes no sense considering that the main source of non-aeronautical revenue comes from business units. However, most airports have high values of commercial units, but which do not operate or are still available for rent. Therefore, the model understands that increases in business units have a negative impact on revenue when not properly used.

The variables PM and RU have positive influences on revenue and the highest standardized β is related to passenger movement, i.e., this is the variable with the highest explanatory power in the model. Keeping the other values constant, a unit increase in airport handling generates an increase of USD 2.504 in the value of RNA, motivated by the fact that the greater the passenger movement, the greater the revenue generation within the unit (Graham, 2008). For retail units, keeping the other variables constant, increases in the value of RU have an impact of USD 35,366.824 on revenue, even though much of the profit is related to commercial facilities and airports receiving high revenue from concessions to provide units with low investment costs, which boosts revenue generation. Equation 12 demonstrates the result of the simplified regression model.

$$\widehat{NAR_\iota} = 1391689{,}344 + 2{,}504PM_i - 0{,}298CC_i - 36066{,}255CU_i + 36070{,}381FU_i + 35366{,}824RU_i \quad (12)$$

In relation to the model 2, the dependent variable is the Aeronautical Revenue (AR). In making the correlation studies, simulations with different variables and significance tests, the model considered only the explanatory annual movement and aircraft movement. However, when generating the new model, the aircraft movement variable had a VIF value of 11.23 and a TOL of 0.089, which is a multicollinearity signal identified with the diagnosis of collinearity. This done, the aircraft movement variable (AM) was removed from the model and a new regression was generated. When generating the new model, the adjusted R^2 increased from 0.916 to 0.997, that is, removing the AM variable gave a greater explanatory power to the model.

The PM variable, keeping the other values constant, has a positive impact of USD 2.504 on the AR value for the airport, i.e., the higher the passenger movement, the higher the aeronautical revenue of the airport. This is because the RAs come from moving aircraft within the unit from landing, boarding / landing fees, parking and handling charges. Therefore, if an airport moves more passengers, it tends to have a larger airport operation in the unit, increasing the aeronautical revenue values, as shown in Equation 13.

$$\widehat{AR_i} = 974{,}941 + 1{,}967PM_i \tag{13}$$

In relation to model 3, the dependent variable was Aeronautical Costs. When performing the previous regression analyzes, the variables aircraft movement, peak hour passengers and passenger terminal area presented a level of significance. The others were removed because they were not linear or not within the confidence level of the research. The PPH variable resulted in a VIF value of 13.24 and a TOL value of 0.075, which is a multicollinearity signal. By generating the collinearity diagnoses and proving the result, the PPH variable and the model constant were removed and a new regression was generated with the TA and PM variables. The new model had a change in the adjusted R^2 value from 0.887 to 0.920 and a Durbin-Watson value of 1.610. The removal of the variable and constant that did not present a significance level adopted in the research gave greater explanatory power to the model.

An increase in the PM variable, with a higher standardized β, keeping the others constant, has an impact of USD 156.330 on the value of CT. This can be explained by the fact that aircraft moving within the yard generates domestic / international boarding and domestic / international landing costs, which are the highest cost values for the airport. An increase in the TA variable, keeping the others constant, has an impact of USD 821.229 on the value of aeronautical costs. This increase is expected because the main customer functionality, comfort and safety activities are performed at the terminal, which significantly increases unit costs, as shown in Equation 14.

$$\widehat{AC_i} = 156{,}330AM_i + 821{,}229TA_i \tag{14}$$

In relation to model 4, previous regression studies showed a significance level only for the variables Non-Aeronautical Revenue and Total Business Units, with an adjusted R^2 of 0.794 and a Durbin-Watson value of 1.926. The model showed that an increase in the CC variable, keeping the others constant, has an impact of USD 0.282 on the value of the NAC. This is due to the fact that increases in CC lead to higher costs with storage and foreman control and cargo transportation operations within the airport. Increases in the CU variable, while keeping the others constant, have an impact of USD 11,660.542 with higher standardized β. This is due to the fact that airports declare high numbers of total business units within their units being out of operation or available for concession. The model understands that they are all operating and offers greater explanatory power for generating costs within a small airport, according to Equation 15.

$$\widehat{NAC_i} = 195121{,}247 + 0{,}282CC_i + 11660{,}542CU_i \tag{15}$$

Replacing Equations 12, 13, 14 and 15 by Equation 7 and simplifying, gives a general financial result equation for each airport considered in the survey, as shown in Equation 16. In addition, the same methodology is applied for other two years considered in the survey obtaining a three-year analysis of the airport's financial performance, according to Equations 16, 17 and 18

$$\mathrm{FR}_{i_{2015}} = -183181{,}603 + 4{,}467PM_{i2015} - 0{,}370CC_{i2015} - 24405{,}699CU_{i2015} + 36070{,}382FU_{i2015} + 35366{,}241RU_{i2015} - 155{,}560AM_{i2015} - 821{,}229TA_{i2015} \quad (16)$$

$$\mathrm{FR}_{i_{2016}} = 237480{,}009 + 3{,}233PM_{i2016} - 1720{,}756PK_{i2016} - 14923{,}833CU_{i2016} - 122{,}264AM_{i2016} - 675{,}826TA_{i2016} \quad (17)$$

$$\mathrm{FR}_{i_{2017}} = -1063979{,}950 + 2{,}183PM_{i2017} + 8219{,}820FU_{i2017} - 517{,}769TA_{i2017} - 4629{,}834CU_{i2017} \quad (18)$$

By analyzing the general equations, the variables PM, FU and RU have a positive impact on the FR. Airports with high passenger movement, retail and food units have better financial performance. The results presented, connects with the studies of Li and Papatheodorou (2010), showing that the increase in passenger movement together with the commercial structure of airports positively impacts airport revenues. Thus, it is necessary the joint focus on increasing the PM and RNAs of the units to increase revenue per airport passenger.

The other variables CC, CU, AM, TA and PK, with negative yield for the airport, are explained by the present study considering the unit costs, leading to the analysis that the revenue generated can also generate higher costs for the airport, negatively affecting its financial result. In this context, the studies of Li (2014) and Cooper (1987), stress the relevance of analyzing the general activities and processes of airports that generate increased costs. In the case of small airports considered, the model shows that directing resources in variables with negative yield directly impacts the financial performance of the units. Therefore, investments in the variables analyzed generate an increase in CAs and CNAs in the long-term financial result of the small airports.

Asaaf (2009) and Lopes (2014) show the needs of investments to increase the efficiency and productivity of small ones in relation to large airports. Therefore, the models presented show precisely the impact of each variable analyzed on the annual financial performance of the units, in addition to the relationship between them to direct the resources of the units to optimize the investments of the area

Table 6 presents the results of the three least efficient airports and the variable with the highest analysis weight, that is, in terms of data that presented the most explanatory relevance for the model.

Table 6: airports in worst financial condition.

Airport	Financial results	Variable
Cruzeiro do Sul International Airport	-4.737.012,308	AM
Petrolina Airport	-3.664.910,513	
Boa Vista International Airport	-3.527.821,026	

Source: research data.

The Table 7 presents the results for the 3 most efficient airports compared to the others.

Table 7: airports in better financial situations.

Airport	Financial results	Variable
Carajas Airport	-541.974,102	PM
Juazeiro do Norte Airport	-749.448,974	
Joinville Airport	-1.046.645,641	

Source: research data.

Tables 6 and 7 represent, in terms of data, the variables with the highest explanatory power, categorized according to the standardized β representing the weight of each variable. For airports with higher losses, aircraft movement is the variable that represents the highest cost to units. This may be due to low passenger movement and aircraft do not take off at their maximum operating efficiency or stay in the unit generating maintenance and permanence costs. As for the most financially efficient airports, passenger movement has the largest explanatory weight motivated by the high generation of NARs by passengers.

The results of the survey identify the factors that positively and negatively impact the financial performance of small airports. This model becomes even more relevant when analyzing the explanatory variables in the context of cost and revenue, generating a financial result forecast equation relating the other variables that characterize the airports of the research. From this, the study contributes and can serve as a basis for decision-making of the business activity of the sector by showing unity the other variables related to the airport's profit directing the management of the unit.

Conclusion

This study presented conceptual mathematical models of airport financial efficiency that can serve as a basis for identifying the variables associated with the financial performance of small airports. The relevance of the study lies in the methodological contribution to consider ARs, NARs, ACs and NACs in the same study, making it possible to perform comparative analyzes between cost, revenue and physical characteristics applicable to small airports.

The results for the years considered in the study were consistent presenting uniformity in the impact of the independent variables in relation to the dependent variable for each year. It is noteworthy that airports are affected by endogenous and exogenous factors controlling the organization. In this context, it is noted the relevance of NARs for small airports, as ARs generate lower revenues and higher costs, which is a type of revenue that can be increased through management efforts. The movement of passengers presents a greater difficulty to be controlled because it is influenced by reasons such as geographical location of airports, air ticket values, low economic and social development of the region and tourist seasonality. These factors can not be controlled exclusively by the airport manager.

The study shows the weight of each variable in the financial results of small airports, being fundamental for prioritizing the activities of the sector. In addition to serving as an aid to managers in the area, the research implies the characterization of the main variables related to financial performance through the method and technique employed.

The study also has relevant theoretical implications for considering both the revenue and cost structure and the characteristics of a small airport, filling gaps left in airport financial performance studies (Graham, 2009 and Li, 2014).

Some limitations were identified in the study, as the data are made available by airport managers to reduce the sample to only the units managed by Infraero, which makes available in the report the variables considered in the survey.

For future studies, it is recommended to apply the methodology in a panel data analysis considering a historical series also inserting small airports from other countries for a comparative analysis of the performance variables. In addition, considering *dummies*, such as geographic location of each unit and local socioeconomic factors, that may have significant impacts on results, may present a broader range of analyzes applicable to small airport businesses.

Acknowledgments

National Council for Scientific and Technological Development (CNPQ) / Federal University of Goiás (UFG) – Scientific Initiation scholarship (IC), The State of Goiás Research Foundation (FAPEG) and the MTOW – Air Transport Innovation Research Group.

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